

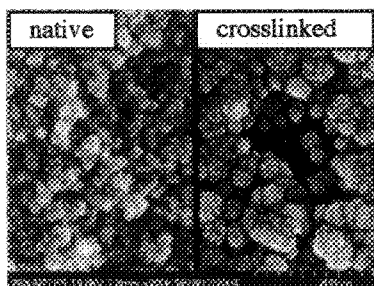
Mechanically Strong, Polymer Crosslinked Aerogels (X-Aerogels)

by

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Aerogels comprise a class of low-density, highly porous solid objects consisting of dimensionally quasi-stable self-supported three-dimensional assemblies of nanoparticles. Aerogels are pursued because of properties above and beyond those of the individual nanoparticles, including low thermal conductivity, low dielectric constant and high acoustic impedance. Possible applications include thermal and vibration insulation, dielectrics for fast electronics, and hosting of functional guests for a wide variety of optical, chemical and electronic applications. Aerogels, however, are extremely fragile materials, hence they have found only limited application in some very specialized environments, for example as Cerenkov radiation detectors in certain types of nuclear reactors, aboard spacecraft as collectors of hypervelocity particles (refer to NASA's Stardust program) and as thermal insulators on planetary vehicles on Mars (refer to Sojourner Rover in 1997 and Spirit and Opportunity in 2004).

Along these lines, the X-Aerogel is a new NASA-developed strong lightweight material that has resolved the fragility problem of traditional (native) aerogels. X-Aerogels are made by applying a conformal polymer coating on the surfaces of the skeletal nanoparticles of native aerogels (see Scanning Electron Micrographs). Since the



relative amounts of the polymeric crosslinker and the backbone are comparable, X-Aerogels can be viewed either as aerogels modified by templated accumulation of polymer on the skeletal nanoparticles, or as nanoporous polymers made by templated casting of polymer on a nanostructured framework. The most striking feature of X-Aerogels is that for a nominal 3-fold increase in density (still a ultralightweight material), the mechanical strength can be up to 300 times higher than the strength of the underlying native aerogel. Thus, X-Aerogels combine a multiple of the specific compressive strength of steel, with the thermal conductivity of styrofoam. X-Aerogels have been demonstrated with several polymers such as polyurethanes/polyureas, epoxies and polyolefins, while crosslinking of ~35 different oxide aerogels yields a range of dimensionally stable,

porous lightweight materials with unique combinations of structural, magnetic and optical properties.

The main theme in materials development for space exploration is multifunction. For example, use of one material for thermal insulation/structural component will free weight for useful payload. In that regard, X-Aerogels are evaluated at NASA for cryogenic fuel storage tanks and for spacesuits. Along the same lines, major impact from X-Aerogels is also expected in commercial applications for thermal/acoustic insulation, in catalytic reformers and converters, in filtration membranes and membranes for fuel cells, as platforms for optical, electrical and magnetic sensors, and as lightweight structural component for aircraft and satellites.